Plans to Search for New Particles Decaying to Dijets

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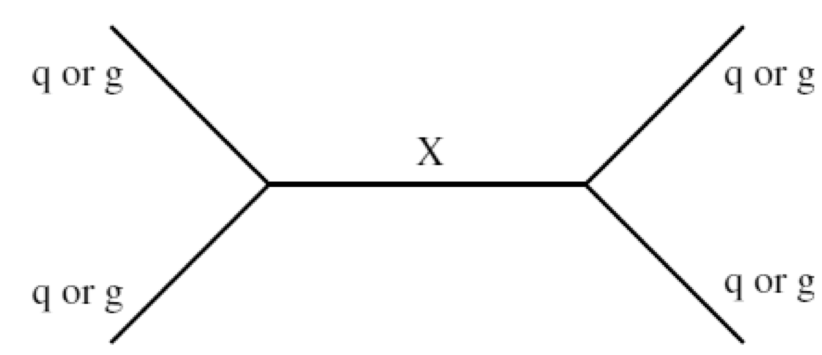
Introduction

Motivation

The Standard Model (SM) is the current theory of quarks and leptons and their electromagnetic, weak, and strong interactions. However, it is not a complete theory because it has important unanswered questions, such as: Why do quarks come in different flavors? Why are the quarks arranged in generations? Why are there four different forces? How do we unify gravitation with the other forces?

There are new theories that try to address these questions. As these theories try to answer these unanswered questions, they often predict extremely short-lived particles called resonances. The Resonance models which are in the table are considered for our research.



Model Name	X	Color	J^P	$\Gamma/(2M)$	Chan
Excited Quark	q*	Triplet	$1/2^+$	0.02	qg
E_6 Diquark	D	Triplet	0^+	0.004	qq
Axigluon	A	Octet	1^+	0.05	$q\bar{q}$
Coloron	C	Octet	1^-	0.05	$q\bar{q}$
RS Graviton	G	Singlet	2^-	0.01	$q\bar{q}$, gg
Heavy W	W'	Singlet	1^-	0.01	$q\bar{q}$
Heavy Z	Z'	Singlet	1^-	0.01	$q\bar{q}$

Dijet Mass

The dijet system is composed of the two jets with the highest p_T in an event (leading jets), and the dijet mass is given by

$$m = \sqrt{(E_1 + E_2)^2 - (\vec{p}_1 + \vec{p}_2)^2}$$

Both leading jets are required to have pseudorapidity $|\eta|<1.3$. The data is selected by requiring at least one jet in the high level trigger with $p_T > 110$ GeV/c. Backgrounds from cosmic rays, beam halo, and detector noise are removed by requiring $\not{E}_T/\sum E_T < 0.3$ and total transverse energy is less than 10 TeV.

Dijet Mass Distribution

Signal

The process of q*→qg, G→qq and G→gg were produced using PYTHIA + CMS simulation at three different masses of 0.7 TeV, 2 TeV and 5 TeV. Because of different detector response, ISR and FSR, the resonance shapes are different.

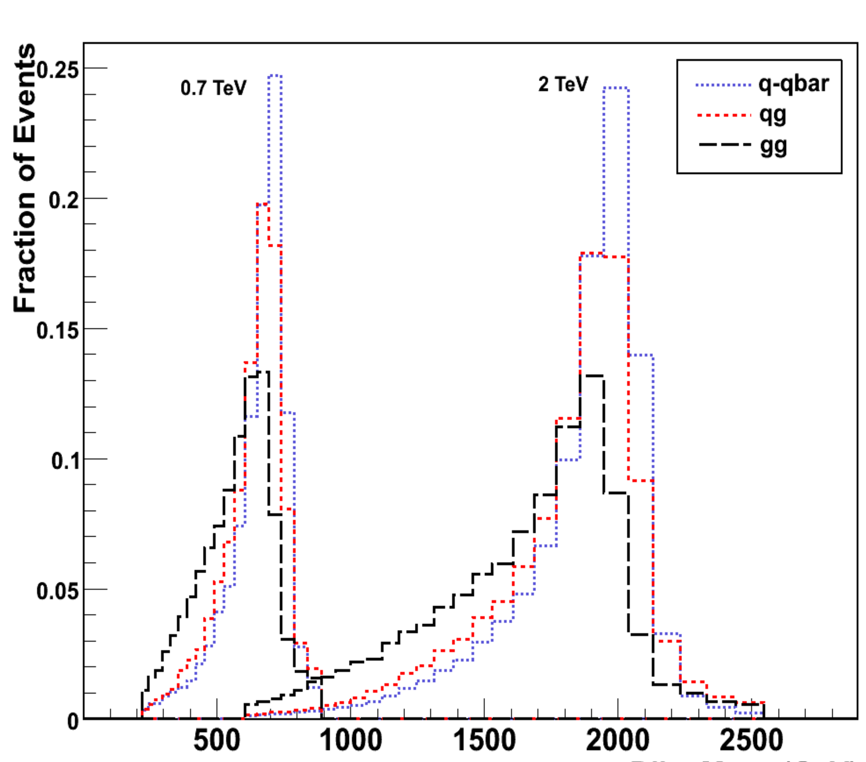


Fig. 1. Dijet resonances shapes for three different parton pair resonance.

Pseudo-data

We use a simulated pseudo-data sample corresponding to 10 pb^{-1} of integrated luminosity from the CMS experiment at a collision energy of 10 TeV to test our plans to search for new particles decaying to dijets.

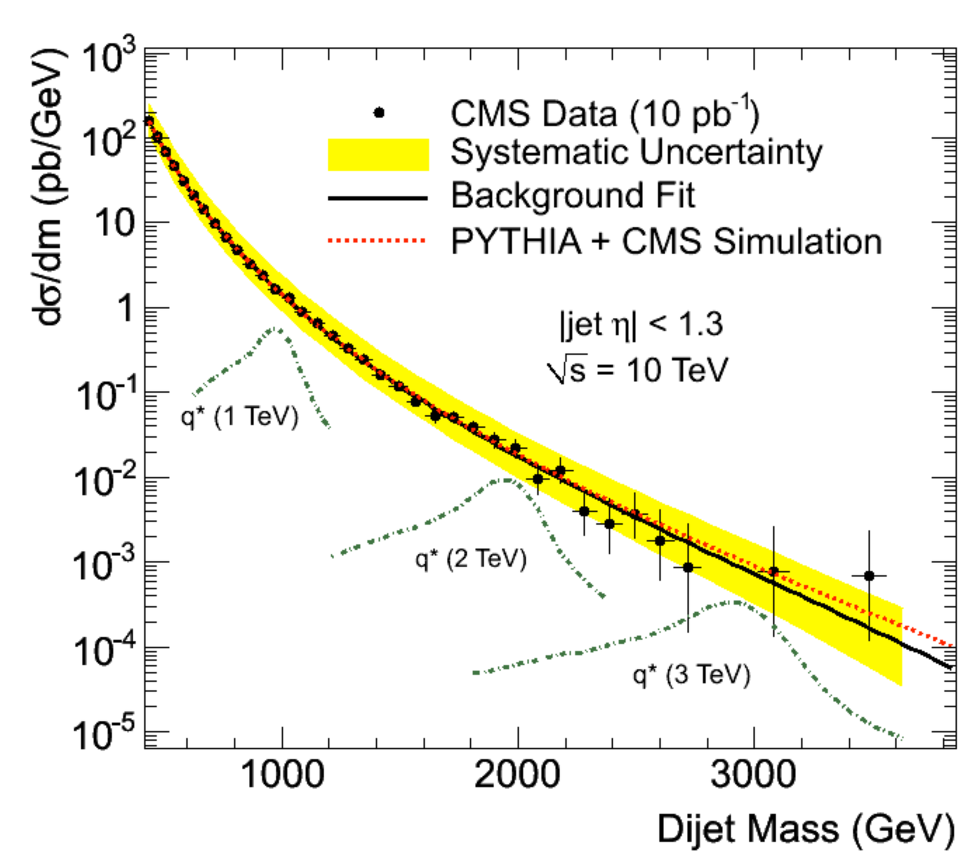


Fig. 2. The dijet mass distribution compared to fit and simulation of QCD and excited quark signals.

Data Compared to Fit

(Data-Fit)/Fit plot as a function of dijet mass shows that q* signals with resonance mass less than 2 TeV could be seen or excluded.

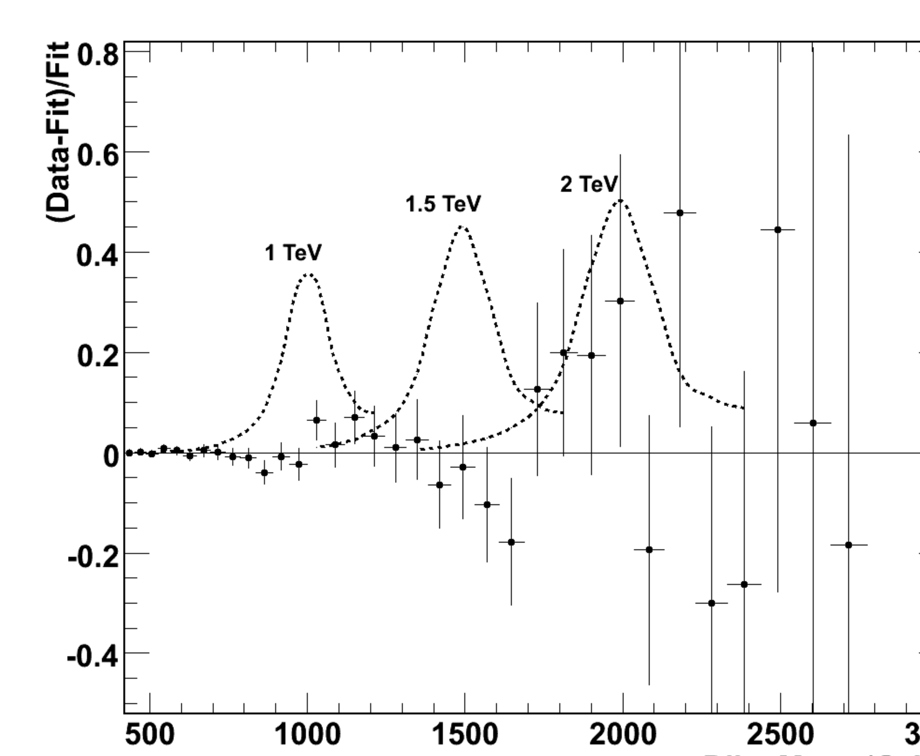


Fig. 3. The fractional difference between the dijet mass distribution (points) and fit (line) is compared to simulations of excited quark signals in the CMS detector (dashed curves)

Search for Dijet Resonances

Likelihood

Likelihood as a function of signal cross section is used to set limits.

$$L = \prod_i \frac{\mu_i^{n_i} e^{-\mu_i}}{n_i!}$$

$$\mu_i = \alpha N_i(S) + N_i(B)$$

n_i : measured number of events

$N_i(B)$: number of expected events from background

$N_i(S)$: number of signal

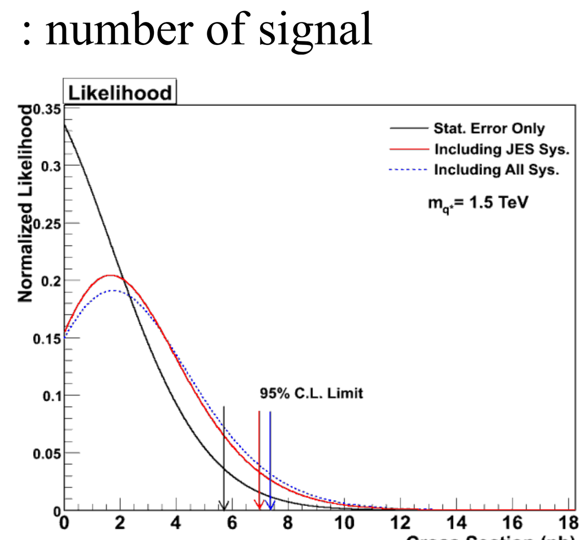


Fig. 4. Likelihood distribution.

Systematic Uncertainties

The following source of systematic uncertainty have been considered so far:

- Jet Energy Scale (JES)
- Background parametrization
- Luminosity

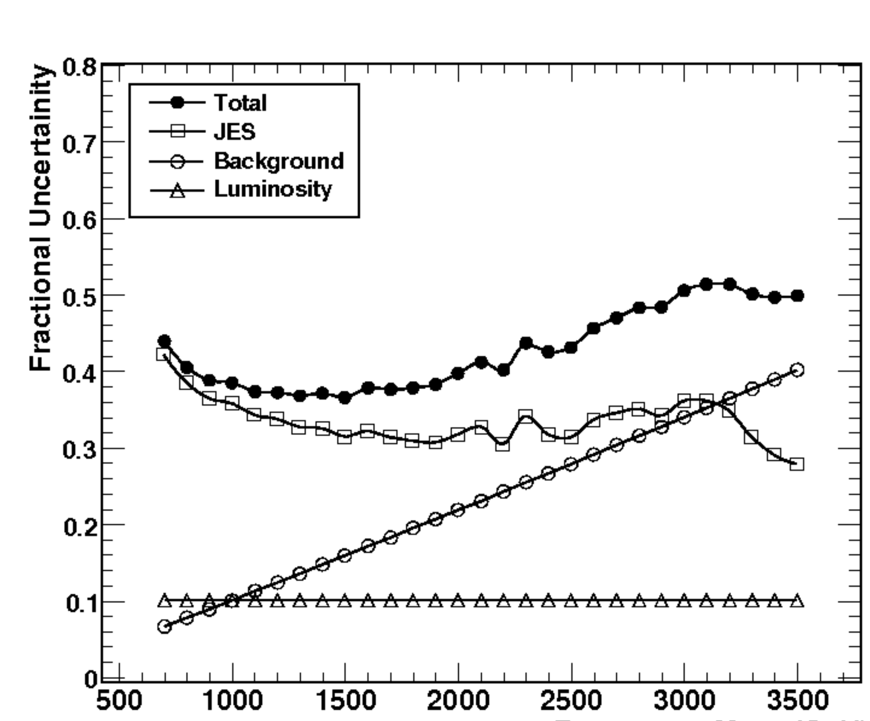


Fig. 5. Fractional systematic uncertainties.

Results

From this pseudo-data sample we exclude at 95% CL.

Model Name	95% C.L. Excluded Mass (TeV) CMS ($10\ pb^{-1}$, $\sqrt{s} = 10\ TeV$)
Excited Quark	$M(q*) < 1.8$
Axigluon, Coloron	$M(A) < 1.8$
E_6 Diquark	$M(D) < 1.0$, $1.3 < M(D) < 1.7$

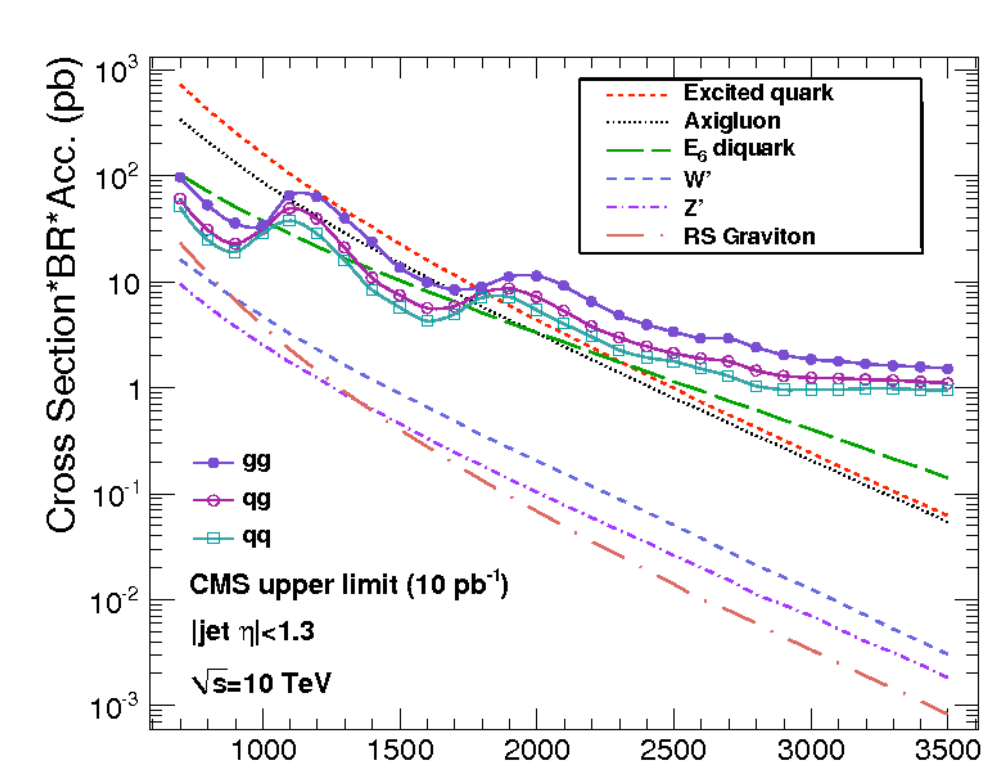


Fig. 6. Dijet resonance sensitivity for 10 pb^{-1}.

References: CMS PAS QCD-09-006 , CMS AN 2009/070 , CMS AN 2009/145